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NOTES ON THE LIFE CYCLE OF THE NANTUCKET TIP MOTH

RHYACIONIA FRUSTRANA COMST.

IN SOUTHEASTERN LOUISIANA

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* - This series of publications releases data gathered in connection with investigations being carried on at the Southern Station. The information contained in them is subject to correction or amplification following further investigation. - Editor

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The Nantucket tip moth (*Rhyacionia frustrana* Comst.) is a small tortricid moth occuring generally throughout the pine forests of North America. The larvae are responsible for an immense amount of damage to small pines, both in natural reproduction and in planted stands (1).

In 1915, W. R. Mattoon, of the United States Forest Service, described the conspicuous damage of the Nantucket tip moth on shortleaf pine (*Pinus echinata*) in the South (2), but somewhat under-rated the potentialities of the insect for mischief.

In 1919-1920 the Great Southern Lumber Company began artificial reforestation with loblolly pine (*Pinus taeda*) at Bogalusa, Washington Parish, La., on an unprecedented scale, and in 1921 the tip moth began to be conspicuous in the planted stands. In 1923 and 1924 the company made unsuccessful attempts to control the pest by cutting off the infested tips and burning them. At the end of the 1924-1925 planting season, damage by tip moth had become so severe that the company abandoned the use of loblolly pine for planting, despite the ease with which it could be grown and its suitability for paper pulp.

The larva of the Nantucket tip moth seriously injures young trees of all the southern pines except longleaf pine (*Pinus palustris*) and slash pine (*P. caribaea*). The longleaf-loblolly pine hybrid, (*Pinus sondereggeri*), is frequently as severely injured as the loblolly pine parent. Practically all western American pines, Mediterranean pines, and oriental pines capable of growth in the South are subject to serious tip moth injury. Slash pine is attacked but not severely injured. Authentic records of Nantucket tip moth attack on longleaf pine are certainly rare, if not entirely lacking.

There may be a direct relation between the free resin flow of slash and longleaf pines and their resistance to tip moth attack. These two species are practically the only turpentine-producing species of the United States.

Tip moth injury to the individual loblolly or shortleaf pine tree consists of repeated killing of the terminal shoots and usually most of the larger laterals, resulting in delayed height growth, deformation of the main stem, the formation of witches' brooms, and the loss of much energy through the production of wood later

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[1] Presented before New Orleans Academy of Sciences, New Orleans, La., on March 23, 1934.

killed by the burrowing larvae. (figs. 1-2) The most serious killing of twigs and formation of witches' brooms occur on trees less than eight feet high, but the more serious deformations of the stems often occur on trees from ten to twenty feet high. The delay in height growth lengthens the time required for the trees to reach merchantable size, and the crooks in the stem and the increased number and size of knots from the proliferating branches lower the quality of the wood.

Damage is greatest in even-aged stands of loblolly pine or shortleaf pine coming in on abandoned fields, and in pure, even-aged plantations of these two species, especially on soils not particularly adapted to their requirements.

The Nantucket tip moth is one of the most difficult of forest insects to control directly, as it spends most of its life inside the twig, out of reach of any dust or spray. It occurs in so many twigs, on trees so widely distributed on rough and relatively inaccessible sites, that removing and destroying infested material is not economically feasible. Therefore indirect or silvicultural control must be relied upon. There is definite evidence that growing the trees in dense stands minimizes the damage. (Fig. 3) Other forms of indirect control are discussed elsewhere (3).

The present study is concerned solely with the number of successive generations of the moth per year on southern pines in southeastern Louisiana. Graham indicates that the geographic variety (*Rhyacionia frustrana bushnelli*) has one generation per year in the Lake States and in the Black Hills, but two in Nebraska, and that (*R. frustrana*) in the South "may have three or possibly four. (1)" Graham's statement is at variance with the theories of other authorities, who have contended that what appear to be successive generations in the South are in reality overlapping broods. The point is important, because the principal southern host species are multinodal pines, that is, pines making two or more successive spurts of terminal growth during the year. In addition, these pines, especially loblolly and shortleaf, are conspicuously able to form adventitious buds in the fascicles of needles on the highest part of sound stem left in a terminal, the tip of which has been injured. Hence these pines can continue height growth from a succession of such points after three or four successive injuries, instead of straightening up the highest existing side branch as uninodal northern conifers do after similar injury. In other words, the actual and potential harmfulness of a shoot-boring insect on multinodal southern pines depends to a large extent on its ability to attack the pine afresh as often as the pine puts out new growth. Moreover, the more generations the insect has per year, the faster it can build up a dangerously large population from a small parent stock surviving the winter, the faster it can invade new stands, and the more seriously it can weaken the host plants by sheer force of numbers.

General observations of the appearance of small and large larvae, and of pupae, in the twigs of young loblolly pine in the Bogalusa plantations, and of fresh and old adults among the foliage, indicated fairly clearly that there were four complete generations a year. The evidence was strengthened by two additional facts. First, the current larvae or pupae were found consistently in the new wood arising from adventitious buds formed after the injury caused by what were considered to be the previous generation of larvae. Second, in forest nursery beds, seedlings lifted in December had pupae in growing tips known to have developed during September; such seedlings, if they had been attacked earlier in the season, would have shown unmistakable signs of the earlier injury, and in many instances would not have made the September growth.

The evidence in favor of the theory of four successive generations appeared stronger than that in favor of the theory of overlapping broods. It could be made practically conclusive by demonstrating, under controlled conditions, that the moths could develop from egg to adult during an eight to ten weeks period coinciding with one of the apparent generations during the active growing season.

This demonstration was attempted during 1929 and 1930 by means of a series of cages arranged on the tops of young loblolly pines at Bogalusa, La. The 1929 cages were made of voile, reinforced with light wire hoops. The voile at the bottom of each cage was tied tightly around the stem of the tree, a foot or so below the terminal bud, and the cage was kept extended by a string running from the top of the cage to a tripod of poles erected above the tree. Ten such cages were set up in February, about the time the first adult moths emerged from the pupal cases in which they had passed the winter. All infested twigs were removed from the parts of the trees enclosed in the cages. In five of the cages live adults were inserted (5 to 20 adults per cage) to oviposit; no sex determinations or records of mating were made, but a sufficient variety of numbers were used to give reasonable hope of success in at least part of the cages. Meanwhile the other five cages were kept closed, without moths, as a check, to indicate whether all living moths had been removed, or whether eggs or small larvae had been overlooked. After two or three weeks, the moths inserted in the first five cages were recovered (usually dead and often badly disintegrated) to avoid confusing them with any of their descendents that might emerge later in the season. Evidences of fresh injury on the twigs within the cages were observed as opportunity offered, and at the time of the second flight of the year adults and fresh pupal cases found in the cages were counted and recorded. Then live adults of the second flight were inserted in some of the check cages, left two or three weeks, and recovered, while the rest of the check cages were again retained as checks. The process was repeated a third time, and then, in 1930, the entire experiment was repeated on ten fresh trees, with new cages of improved design, and continued on one tree used as a check throughout 1929.

During 1929 several of the check cages became infested, thus preventing the results of the artificial infestations from being conclusive. It was fairly clear, however, that the infestation of the checks had taken place where infested branches outside the cages had pressed against the voile. This was guarded against in 1930 by making the bottom half of each cage of more closely woven cloth (unbleached muslin) and by coating the stem both inside and outside the cage with tree tanglefoot. (Fig. 4) During the first generation period in 1930, two checks developed what may have been tip moth infestations on twigs in contact with the voile on the inside, and it was thought that moths might have oviposited on the outside of the voile and the newly hatched larvae might have wriggled through. Thereafter, all twigs in contact with the cages, either inside or out, were carefully cut away, and no further trouble was experienced.

A new generation did not develop in every cage in which moths were inserted, in some cases apparently because too few adults were used, or the moths were inserted too late in the season, and in others clearly because the cutting back of the pine tops prevented the development of enough new growth to bring the larvae to maturity. In practically every cage in which conditions were reasonably favorable,

however, a new generation did develop to maturity, and always in a period of eight to ten weeks, corresponding with the time between flights in the surrounding plantations. The details of all of these successful generations are shown in Table 1. The irregularity of field trips prevented the obtaining of dates of emergence of the third generation in either year, but the fact that it did mature is beyond doubt, as at least one adult was recovered in each case. The fourth generation was not produced under controlled caging, but as this is the generation killing the last (September) node put on by the pine during the year, and passing the winter in the pupal stage in the dead twigs, there is no chance of confusing it with any of the other three generations, which pupate in April-May, June-July, and middle August, respectively.

The most clear-cut evidence of all was obtained from the second generation in the 1930 cages. Adults were obtained July 14, 1930, as the offspring of adults inserted May 14, 1930, in two separate cages. One of these cages had been free from all signs of tip moths and tip moth activity since January 12, 1930, and the other since July 4, 1929. While the moths in these two cages were passing through their complete life cycle, seven check cages, of which two had contained moths of the first generation, remained absolutely free from moths of the second generation and from signs of their activity.

On the basis of the evidence obtained in this study, it may be concluded that the Nantucket tip moth has four successive generations per year on young pines of susceptible species in southeastern Louisiana.

The occurrence of four successive generations of the tip moth is significant for two reasons. First, even a pine having four successive periods of height growth per year is hard put to it to overcome the effect of injury by the insect. An exotic susceptible to attack, and having a uninodal habit, or less than four nodes, could hardly be considered promising in this region, and even the susceptible native species cannot be considered promising on sites so unfavorable as to reduce the number of nodes per year to three or less during the years of the tree's life in which attacks are most serious. Second, there is the ever-present danger that factors of climate or food supply will enable the insect to build up threateningly large populations during the course of a single season, even from fairly small over-wintering parent stocks. This in turn is an argument against the establishment of large, pure, even-aged stands of highly susceptible species, such as loblolly and shortleaf pines, because such stands, when young and within reach of the low-flying moths, furnish the maximum possible supply of food.

Table 1

Cage	Date of last observation of tip moths or of signs of their work	Date of insertion of adult breeding stock	Date of discovery of adult offspring of breeding stock	Generation produced in cage
1, 1929	Feb. 15, 1929	Mar. 4, 1929	May 15, 1929	1
3, 1929	Feb. 15, 1929	Mar. 9, 1929	May 15, 1929	1
4, 1929	Feb. 15, 1929	Mar. 16, 1929	May 15 1929	1
A, 1929	Apr. 10, 1929	May 15, 1929	July 4, 1929	2
B, 1929	Apr. 10, 1929	May 15, 1929	July 4, 1929	2
C, 1929	Feb. 15, 1929	May 15, 1929	July 4, 1929	2
D, 1929	July 4, 1929	July 4, 1929	Sept. 9, 1929	3
3, 1930	Jan. 12, 1930	Mar. 8, 1930	May 14, 1930	1
5, 1930	Jan. 12, 1930	Mar. 8, 1930	May 14, 1930	1
A, 1930	Jan. 12, 1930	May 14, 1930	July 14, 1930	2
E, 1929	July 4, 1929	May 14, 1930	July 14, 1930	2
B, 1930	Jan. 12, 1929	July 14, 1930	August, 1930	3

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Figure 1.

Fairly typical damage to young, planted loblolly pine by Nantucket Tip Moth. The lable in the picture measures 3 by 5 inches. Bogalusa. La.

Figure 2.

Extreme damage to planted loblolly pine by Nantucket Tip Moth; a planted tree nine years in the field and ten from seed, killed back 41 inches in a single season. Bogalusa, La.

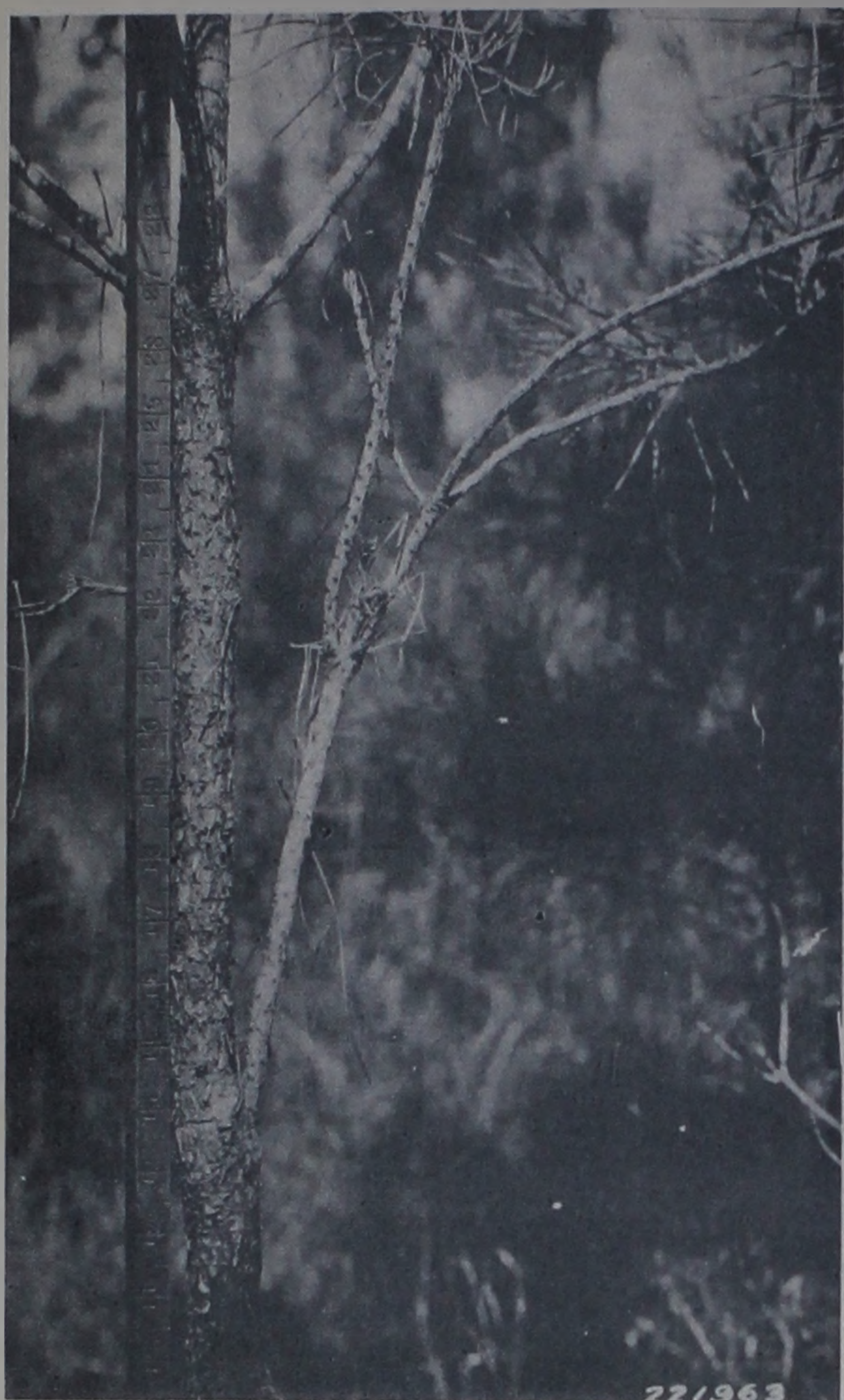

Figure 3.

Loblolly pine at Bogalusa, La. in dense natural stand on soil adapted to the species. Original leader killed back by Nantucket Tip Moth, and forced to one side by the development of a new leader arising from an adventitious bud. The conditions have been such that recovery from tip moth injury has been good.

Figure 4.

Improved type of rearing cage used in study of tip moth at Bogalusa, La. The cloth below the middle wire reinforcement ring is unbleached muslin; that above is voile. Examinations are made by opening the top of the cage.